Final Report for the Agro-Environmental Technology Program

“Greenhouse Raspberry Production for Winter Sales: A Demonstration Project”

Bill Hamilton
Hamilton Orchards
22 West St.
New Salem, Massachusetts 01355

Abstract
Hamilton Orchards in New Salem, Massachusetts established a demonstration project in 2000/2001 growing raspberries in containers in the greenhouse. This project put into practice a system developed at Cornell University, testing the methodology under real-life commercial conditions. The project produced somewhat higher than expected yields (over 1 pint) of very high quality fruit in the first year of production. Production in the second year is expected to be 4-6 pints per plant. The reception in the marketplace was very positive ($3.50 per half-pint). The project compared two of the highest performing varieties, ‘Tulameen’ and ‘Encore’. ‘Tulameen’ was by far the most productive. The project also compared conventional transplants with ‘long cane’ plants and the conventional transplants were more productive. There were unexpected problems with high humidity that led to a significant yield reduction due to reduced pollination success. Solving this problem would have increased yield by about 50%.

Introduction
Massachusetts farms are facing increasing pressures on their profitability and many are meeting this challenge by diversifying their operations, increasing their direct marketing sales, and increasing the efficient use of existing farm assets/resources. This project incorporates all three of these strategies into a new enterprise that may offer growers an exciting new way to add profits to their farm operations: greenhouse raspberry production for winter sales. This is a system that has been developed by Cornell University in collaboration with others in response to high consumer demand for quality fruit year round.

Currently, raspberries and other berries offered in markets in the winter months come from overseas and are fetching a high price of about $3.50 - $6.00 per half pint container. No domestic sources of winter raspberries exist, with the exception of a few producers in a small region in southern California along the coast. The quality of these imported fruits is relatively low considering the perishability of raspberries and the distance traveled before reaching the consumer. Never-the-less, consumers apparently will accept this reduced quality and high price. Raspberries grown closer to the markets offer a much higher quality product and the price makes it a profitable enterprise for growers. So, an opportunity exists during the winter months for Massachusetts growers to sell high quality raspberries to restaurants, retail markets or directly to the consumer.

Many types of farms could incorporate greenhouse raspberry production into their operations. The most obvious would be those that already have greenhouses on-site, but that are not in full use from mid- to late-December to April. For example, growers who are selling Poinsettias are emptying their greenhouses prior to the Holiday season and may not re-fill the houses until bedding plants are started in April-May. Other greenhouse operators may find that raspberry production is more profitable than some other crops (e.g., geraniums) that might be occupying bench space at that time of year. In addition, fruit growers who want to expand their marketing window with this system may find that the investment in a simple greenhouse structure is justified by the returns gained in this system. In each of these cases, the greenhouse raspberry production system offers an opportunity to realize returns on some level of capital investments (greenhouse, land, equipment, storage, refrigerated transport vehicles, etc.) at a time of year when no money is otherwise coming in.

Hamilton Orchards is, in many ways, a typical New England farm with a range of crops raised (apples, strawberries, summer and fall raspberries, blackberries, and blueberries) and products offered (preserves, baked goods, etc.) for sale in a variety of ways (i.e., wholesale, retail, farmers market, pick-your-own, and value added). The orchard has been in the family since 1925 and has been operated by the current owner, William Hamilton, since 1941. Commercial raspberry production has been a part of the farm since 1928.

While not previously having a greenhouse on site, the orchard has many existing assets that were used in the greenhouse raspberry operation. These include land, water and utilities, equipment for moving pots, cold storage, freezer storage, a commercial kitchen, wholesale accounts and retail opportunities, and a wealth of experience growing raspberries in a field setting. All of these assets were put to work supporting the winter raspberry production enterprise. New investments were also made in the greenhouse structure and heating system, site work, irrigation and fertigation system, plant material and growing medium, trellis materials, pollinators (bumblebees), harvesting supplies and labor. All these investments plus a lot of Yankee ingenuity brought fresh raspberries into the marketplace at a time of year when freshness and wholesomeness are had to find.

Project Summary

The essence of this project was to test-drive a system for producing container grown raspberries in a greenhouse for winter sales. To do so, a 72' x 34' greenhouse was purchased and constructed at Hamilton Orchards. Nine hundred summer- bearing dormant bare-root raspberry plants (600 'Tulameen' and 300 'Encore') were purchased in the spring of 2001 and planted into 1 gals pots filled with Fafard® Professional Formula 3B Mix. They were allowed to grow outdoors for the summer with water and fertilizer being delivered through a drip irrigation system. Canes were supported in the pots with bamboo stakes and the rows supported with a simple trellis system of 5' T-stakes driven into the ground and non-degradable twine strung from stake to stake on both sides of the row to prevent pots from tipping over. These field grown plants remained outdoors until December and then had to be moved into vacant apple storage because of a delay in getting the greenhouse ready. Another 300 'long cane' dormant 'Tulameen' plants were ordered from Washington State and were delivered in November, potted and put directly into cold storage to keep them dormant. Raspberries have a chilling requirement of about 1,000 hours <45˚F which must be satisfied before the plants will break dormancy and produce flower buds and fruit (this chilling requirement is usually met by the middle of December in this area). In this project, the plants were moved into the greenhouse in late January 2001.

Once the chilling requirement was met and the greenhouse was ready, a total of 788 plants were brought into the greenhouse, the canes trellised, and watered with a 100 ppm N fertilizer through a drip irrigation system. Surplus plants remained in the cold storage and were available to replace any plants that failed to break dormancy and grow properly. Plants were placed in double rows (with row centers 5 ft. apart) and in a pot-to-pot spacing so that approx. 25 plants were contained in each 10 ft. length of row. (According to research results, supplemental lighting is not needed to produce a full crop, although lighting speeds the crop development by up to 2 weeks.) Four ceiling mounted fans were used to circulate air down the rows and the temperature in the greenhouse was maintained at 60˚-65˚F day and 40˚-45˚F night.

Flowering began in early March, (6 weeks from the time they were moved into the greenhouse). Bumblebees were brought into the greenhouse at this time for pollination. The first fruit were picked in mid-April (6 weeks from the beginning of bloom). The harvest season continued until the end of May, almost until the field harvest season began in June.

All the fruiting canes were removed after harvest. New primocanes were thinned to 3-4 of the best per pot and headed off at about 4'. The plants were then transplanted into 5 gallon pots and moved outside for the summer (2001). These will be returned to the greenhouse for a second season of productionin 2002. Warm weather conditions delayed the accumulation of chilling hours beyond the expected mid-December target. Plants were moved into the greenhouse (unheated) in December and the heat was turned on in late January. These plants are spaced 22 inches apart in the row, on center (single rows), with 5.5 feet between rows. Plants will be trellised and otherwise managed in the same way as in the previous season. Higher yields are expected from the second fruiting season in the greenhouse. Cornell research predicts a yield of between 8 – 11 half pints per plant in the second and subsequent seasons.

Special Considerations:
Varieties : Researchers at Cornell University identified the varieties 'Tulameen' and 'Encore' as among the most productive and highest quality fruit produced in this system. The majority of the greenhouse space was devoted to 'Tulameen' but included 'Encore' on a trial basis. Two types of 'Tulameen' plants were used, the industry standard dormant bare-root transplants and dormant bare-root 'long cane' plants. The difference between these is that the industry standard transplants have the 1-yr canes cut down to a short 'handle'. They must produce primocanes, which mature and go through the dormancy period before producing flowers and fruit. Long-cane plants retain this 1-yr cane which is a mature fruiting cane. Therefore, they can be brought out of dormancy and fruit right away.

Pollination: Raspberries are self-fruitful plants but do require the presence of a pollinator to transfer pollen and fertilize the flowers. In the past this was a stumbling block for greenhouse fruit production because honeybees did not work will in this setting. In recent years, commercial availability of bumblebee hives has removed this barrier to greenhouse fruit production. Bumblebees work very well in this system and are used to pollinate the flowers.

Insect and Disease Management: The most significant pest problems found by the Cornell research were two-spotted spider mites and powdery mildew. Thrips, aphids, and whitefly could also become a problem. Biological/cultural (non-chemical) control methods for all of these pests are available and well documented. Other raspberry insect pests (tarnished plant bug, sap beetle, cane borers, etc.) were not encountered because they are dormant during the greenhouse production period. Most raspberry diseases do not become a problem because the canopy is not moistened by rain, irrigation, or dew. Circulating the air in the fruiting canopy with fans also helps to suppress the incidence of disease. This system is conducive to minimal-pesticide or even organic production.

Economics. As mentioned above, consumers have shown a willingness to pay from $3.50 to as much as $6.00 retail per 1/2 pint of raspberries in the winter months (depending on the market venue). Building market awareness and reputation is an important element of this project.

Statement of Objectives

⇒ **Objective 1)** to conduct a trial of the greenhouse raspberry production system developed by Cornell University under Massachusetts' climate and market conditions. We propose to follow the guidelines of the Cornell system and fully document our activities so that it can serve as a feasibility study of this system under Massachusetts' conditions.

⇒ **Objective 2)** to offer written and oral documentation and an on-farm workshop for interested growers on how this system has worked at Hamilton Orchards.

Results

Objective 1)

Hamilton Orchards completed its first season of producing greenhouse raspberries in the Spring 2001 season. Up front investments included the purchase, establishment and maintenance of the raspberry plants in pots over the summer of 2000 ($3,000+), site preparation for the greenhouse in the summer/fall of 2000 ($3,000+), and purchase and construction of the greenhouse in the fall and winter of 2000/2001 ($16,000).

Dormant potted raspberry plants were moved from refrigerated storage on January 22. The first pots moved (506 ‘Tulameen’ and 164 ‘Encore’) were plants that had been grown outdoors, on-site, all summer. The remaining pots (118 ‘Tulameen’) were moved into the greenhouse from refrigerated storage on February 12, 2001 and were potted bare-root, long-cane plants purchased from Washington State in the Fall. The two types of plants were used to compare the productivity and production cost between them. Normally refrigerated storage is not needed for this system, but due to a delay in finishing the greenhouse, the plants required protection form temperatures that might damage the crowns (below 10˚F). Controlled temperature storage is more important when using the fall planted dormant long-cane plants because they require a systematic acclimation (increased 5˚F per week over 4 weeks from 35˚F to 55˚F) to growing temperatures in order to develop normally.

First blossoms were noted on the field-grown canes on March 3rd, (6 weeks from the time they were moved into the greenhouse). The first fruit were picked on April 15th (6 weeks from the beginning of bloom). A total of 2,087 1/2 pints of high quality fruit were harvested from the 788 plants for an average of 2.64 1/2 pints per plant. This is similar to the yield achieved in the Cornell trials. Higher yields (50 – 60%) could have been achieved if a pollination problem had been anticipated. All harvested fruit was sold at a consistent price of $42/flat of 12 1/2 pints. This equals $3.50 per harvested 1/2 pint for a total income of $7,304.50. The translates to $2.98 per square foot of greenhouse space. Peak harvest were the weeks of May 6th and May 13th when over 530 1/2 pints were picked each of those weeks.

Pest problems encountered included an infestation of two-spotted spider mites (*Tetranychus urticae*) and European red mites (*Panonychus ulmi*), which occurred first on the long-cane plants brought in from Washington State. Control of this infestation required a dormant application of JMS Stylet oil (ultra-fine parafinic horticultural oil), followed by three releases of predatory mites (*Neoseiulus fallacis*, and *Phytoseiulus persimilis*). Late season problems emerged with powdery mildew and Botrytis cane blight. These were the result of very high humidity in the greenhouse, especially at night. Control was achieved mainly through the increase of night-time temperatures (to lower the relative humidity) and increased ventilation. Future problems with these diseases may be avoided by the use of single rows rather than double rows which will greatly improve the air circulation within the canopy of the rows.

An additional problem related to relative humidity arose which greatly affected the harvested yield of fruit from the plants. This had to do with pollination. Once the plants began to bloom, 1 hive of bumblebees was placed in the green house to pollinate the flowers. First, it soon became apparent that one hive was inadequate to successfully pollinated the huge number of flowers produced by these plants (40-50 buds per terminal on ‘Tulameen’ and 8-10 on ‘Encore’). An additional hive of bumblebees was placed in the greenhouse. Second, misshapen fruit resulting from poor pollination mid season suggested another pollination problem, excessive humidity causing sticky pollen. A recording hygrothermograph was placed in the greenhouse to measure temperature and relative humidity levels around the clock. The grower reported dense fog in the greenhouse after sunset each night which would clear after sunrise in the mornings. This was confirmed by the hygrothermographs which recorded 100% relative humidity every night for 13 – 15 hours. Night-time temperatures were being held at 55˚F. Once the night-time temperatures were brought up to 65˚F, the duration of 100% humidity was shortened by 2-4 hours, but the formation of dense fog each night stopped. This appeared to help the pollination enough to improve the percentage of marketable fruit forming later in the season. As an insurance policy, a third bumblebee hive was placed in the greenhouse. Still, a significant number of fruit failed to form properly and it is estimated that an additional 50% (approx 1,000 1/2 pints or $3,500) might have been brought in from this fruit. The work done in New York was in glass greenhouses with concrete floors which rarely have high humidity. In fact, the Cornell work identified low humidity as a problem (causing poor pollen germination) and requiring the daily wetting of the floors to raise the humidity in the greenhouse.

Objective 2)

Two on-farm meetings were held to show this project to interested growers and others

- April 10, 2001, UMass Extension Fruit twilight meeting
- August 16, 2001, Dept. of Food and Agric. Focus on Farms Berry Tour

Two off-season presentations made at commodity association meetings

- November 2, 2001, New England Vegetable and Berry Grower's Winter Meeting
- January 17, 2002, Connecticut Vegetable and Berry Growers' Conference

An article was written about the project and distributed via:

- Massachusetts Berry Notes, Vol. 13, No. 16
- UMass Extension Agroecology Website
- The Yankee Grower Vol. 3, No. 6 Winter 2001

Multiple newspaper articles were written in local papers about the project, as well.

Discussion

The profitability of this system hinges on the cost of producing the fruit. In this case, the cost for establishing this crop was high, especially since the farm had no existing greenhouse to use. A farm with an existing greenhouse will have a distinct advantage in establishing this system. However, costs beyond that of constructing the greenhouse came to approximately $11.70 per pot (Table 1). The costs included plants and potting material, irrigation supplies, bumblebees and mite predators, trellis support, harvest supplies, and production and harvest labor. Income received from the system (based on harvesting 2.64 half-pints per pot and receiving $3.50 per half-pint) was $9.24 per pot. So, in the first year of this project, returns did not meet the costs. However, the pollination problems reduced marketable yield by approximately one third. This would add approximately $2.77 to the gross income raising it to $12.00 and the net income to 32¢ per pot. (*This calculation does not include the cost of constructing the greenhouse*.)

Table 1. Production costs and returns per pot for the first year of greenhouse raspberry production.

Item	**Cost per pot**
Plants	$1.00
Potting mix and pots	$1.50
Drip irrigation/fertigation system	$0.60
Bumble bees	$0.50
Mite predators	$0.28
Production labor	$2.45
Trellis materials	$0.50
Harvest containers	$0.26
Harvest labor	$1.50
Heat	$3.10
Total	$11.69
Gross Income	$9.24
Net Income	**($2.45)**

The key to profitability of this system is the expected yields in the second and third years where returns are expected to be 8 – 11 half-pints per pot (or $28 - $38 per pot). The cost of production in these years will be similar to that of the initial year. Plant costs will be lower but potting material costs and harvest costs will be slightly higher. The number of pots contained in the greenhouse will be lower because the size of the pots will be larger.

Conclusion

The economics of this project were, while only marginally successful, still quite promising. The Hamiltons identified several 'fixable' problems. First, solving the pollination problem should increase yields by approximately 50%. Second, concentrating primarily on conventional bare-root 'Tulameen' plants (which yielded the highest) will increase the over-all profitability on a square-foot basis. Finally, knowing that the yield increases significantly in the second and third years of production makes the investment in the first year more acceptable.

The goal of this project was to ‘test drive’ this system in the real world and see if it might offer an appealing option for Massachusetts producers. Knowing that it performed well under adverse conditions, suggests that it might work even better for those whose initial investment doesn’t need to be so high. That is, producers who already have existing greenhouse space that can be put into this production system.

The market is very large and can accommodate many local producers. One remaining challenge will be the efficient marketing of this product. For the Hamiltons, one of the most unrewarding elements of the system was having to drive around to many buyers and sell only a few flats at a time. While all the fruit was sold, the time spent driving from one buyer to another was not very efficient. This problem may increase as more people get into this production system. An efficient wholesaling system that doesn’t erase the profit margin for small scale local producers will make this production system take off.